# 5.0 ASSESSMENT OF CONFINED (DIKED) DISPOSAL

This part of the report describes detailed assessments for alternatives involving confined (diked) disposal facilities (hereinafter referred to as CDFs). In general, disposal of dredged material in CDFs is regulated under the CWA. It is also important to note that the CDF itself must comply with the Guidelines if it is sited in waters of the United States. In addition, there may be other regulatory requirements under NEPA and other applicable laws and regulations on a case-by-case basis.

CDFs differ in their geohydrology, sediment chemistry, carrier water removal, contaminant release rates, and contaminant pathways affected. Therefore, the testing and assessments required will vary somewhat accordingly, although the procedures are based on similar scientific and engineering principles. The framework for assessing confined disposal is illustrated in Flowchart 3-3 (21K). The detailed assessments described in this chapter may be performed following a determination of the need for such assessments as described in Chapter 3.

## 5.1 Determination of Characteristics of Confined Sites

Site specification for CDFs in many ways can be more complex than for open-water sites. Real estate considerations are a major factor in determining the availability of potential sites. Most navigation project authorizations require the local project sponsors to provide the lands, easements, and rights of way for CDFs; some authorizations require the sponsor to provide dikes and site management. CDFs therefore represent a substantial economic investment on the part of the sponsor. In many instances, the sponsors will only provide sites which meet short-term requirements, and additional sites may be required in the future. Another consideration for CDF site specification is the fact that such sites are normally visible to the public and are viewed as a competing interest for land use, especially in coastal areas where there is intense pressure for both development and preservation of lands.

A knowledge of CDF site characteristics is necessary for assessments of potential physical impacts and contaminant impacts. Information on site characteristics needed for assessments includes the following:

- Available area and volumetric storage capacity to contain the material for the required life of the site.
- Real estate considerations.
- Site configuration and access.

- Proximity to sensitive ecological environments..
- Topography to include potential changes in elevation and runoff patterns and adjacent drainage.
- Ability of the dredged material to eventually dry and oxidize.
- Groundwater levels, flow and direction, and potential impact on groundwater discharge and recharge.
- Meteorology and climate.
- Foundation soil properties and stratigraphy.
- Potential groundwater receptors.
- Potential alteration of the existing habitat type.
- Potential for effluent, leachate, and surface runoff impacting adjacent ground and surface water resources.
- Potential for direct uptake and movement of contaminants into food webs.
- Potential for volatilization of contaminants.
- Potential for dust, noise, or odor problems.
- Potential to implement management activities when deemed necessary.
- Potential accessibility of the site by the public .
- Contamination history of proposed site.

Field exploration programs are necessary to assess many of the above considerations in determining the suitability of a site for use as a CDF. Foundation explorations are especially important for dike design and groundwater assessments. Additional information regarding sampling techniques and equipment and development of field exploration programs for CDFs is given in EM 1110-2-5027 (USACE 1987).

## 5.2 Evaluation of Direct Physical Impacts and Site Capacity

An evaluation of direct physical impacts and initial and long-term CDF site capacity should precede any evaluations of contaminant impacts, since elimination of alternatives based on unacceptable physical impacts or inadequate site capacity could reduce the need for more expensive and involved testing for contaminant effects.

### 5.2.1 Direct Physical Impacts

Direct physical impacts because of construction of the CDF must be assessed. Such impacts may include alteration of habitat, changes in hydrological conditions (e.g., circulation patterns in surface waters and groundwater recharge), restrictions to navigation, and aesthetic, cultural, and land-use impacts. Guidance on evaluation of such physical impacts in waters of the United States is available (40 CFR 230).

### 5.2.2 Initial Storage Capacity and Solids Retention

A CDF must be designed and operated to provide adequate initial storage volume and surface area to hold the dredged material solids during an active filling operation and if hydraulically filled, to retain suspended solids such that clarified water is discharged. The required initial storage capacity and surface area is governed by zone, flocculent, and compression-settling processes which occur in a CDF during placement of fine-grained dredged material. Procedures to evaluate the required surface area and volume during active filling operations, to estimate effluent suspended solids concentrations, and to design other features for CDFs are described in EM 1110-2-5027 (USACE 1987).

### 5.2.3 Long-Term Storage Capacity

In addition to initial capacity during active filling, an evaluation of long-term storage capacity is required if a CDF is intended for use over multiple dredging cycles. The long-term storage capacity of a given site is dependent on the material consolidation and desiccation properties, climate, and operational conditions. Procedures to evaluate long-term storage capacity of CDFs are provided in EM 1110-2-5027 (USACE 1987).

### 5.2.4 Need for Management Actions

If the evaluation of direct physical impacts and evaluation of site capacity indicate that the site is adequate, the remaining assessments can be conducted. If the evaluations of direct physical impacts and site capacity indicate unacceptable impacts will result or that site capacity is inadequate, management actions can be considered.

Management actions to minimize physical impacts of CDF construction may include site management to reduce effluent solids discharge or dewatering of dredged material between filling opera tions to extend capacity and reduce the need for a larger site. Management actions are described in paragraph 5.4. If the management actions are determined to be effective, the remaining assessments can then be conducted. If not, then the confined-disposal alternative at the site under consideration should be eliminated.

## 5.3 Evaluation of Contaminant Pathways of Concern for CDFs

If the initial evaluation of sediment contamination described in paragraph 3.5.3 reveals that contaminants are not of concern for specific pathways, then no additional contaminant testing is required for those pathways. However, if contaminants are of concern, an analysis of appropriate pathways must be conducted that may include possible testing.

### 5.3.1 Contaminant Pathways for CDFs

The possible migration pathways of contaminants from confined disposal facilities in the upland environment are illustrated in Figure 5-1 (6K). These pathways include effluent discharges to surface water during filling operations and subsequent settling and dewatering, rainfall surface runoff, leachate into groundwater, volatilization to the atmosphere, and direct uptake. Direct uptake includes plant uptake and subsequent cycling through food webs and direct uptake by animal populations living in close association with the dredged material. Effects on surface water quality, groundwater quality, air quality, plants, and animals depend on the characteristics of the dredged material, management and operation of the site during and after filling, and the proximity of the CDF to potential receptors of the contaminants.

Migration pathways affected by nearshore CDFs are illustrated in Figure 5-2 (7K) and include all of the pathways previously discussed. Additional considerations for nearshore sites (with one or more sides within the influence of water level fluctuations) are soluble convection through the dike in the partially saturated zone and soluble diffusion from the saturated zone through the dike. Groundwater seepage into or through the site can also be a factor affecting contaminant migration. These additional potential fluxes primarily affect the surface water pathway.

### 5.3.2 Geochemical Environments for CDFs

When dredged material is placed in an upland environment, physical and/or chemical changes may occur (Francingues et al. 1985). The dredged material initially is dark in color and reduced, with little oxygen. If the material is hydraulically placed in the CDF, the ponded water will usually become oxygenated. This may affect the release of contaminants in effluent discharged during hydraulic filling.

Once disposal operations are completed, and any ponded water has been removed from the surface of the CDF, the exposed dredged material will become oxidized and lighter in color. The dredged material may begin to crack as it dries out. Accumulation of salts will develop on the surface of the dredged material and especially on the edge of the cracks. Rainfall events will tend to dissolve and remove these salt accumulations in surface runoff. Certain metal contaminants may become dissolved in surface runoff.

During the drying process, organic complexes become oxidized and decompose. Sulfide com pounds also become oxidized to sulfate salts, and the pH may drop drastically. These chemical transfor mations can release complex contaminants to surface runoff, soil pore water, and leachate. In addition, plants and animals that colonize the upland site may take up and bioaccumulate these released contaminants.

Volatilization of contaminants depends on the types of contaminants present in the dredged material and the mass transfer rates of the contaminants from sediment to air, water to air, and sediment to water. Release of the dredged material slurry above the water level in the CDF surface will enhance volatilization as the slurry impacts the CDF surface, creating turbulence and releasing dissolved gases. The transfer rate for organics such as polychlorinated byphenyls (PCB)s from water to air is generally slower than from sediment to air (Thibodeaux 1989). Therefore, the inundated dredged material prior to dewatering is less likely to produce volatiles than the sediment as it dewaters and dries. ..

CDFs constructed totally or partially in water will usually receive dredged material until the final elevation is above the high-water elevation. Three distinct physicochemical environments may eventually exist at such a site: upland (dry unsaturated layer), intermediate (partially or intermittently saturated layer), and aquatic (totally saturated layer) (Lee et al. 1986).

When material is initially placed in an in-water CDF, it will all be flooded or saturated throughout the vertical profile. The saturated condition is anaerobic and reduced, which favors immobility of contaminants, particularly heavy metals. After the site is filled and dredging ceases, the dredged material above the water level begins to dewater and consolidate through movement of water downward as leachate, upward and out of the site as surface drainage or runoff, and laterally as seepage through the dike. As the material desiccates through evapotranspiration, it becomes aerobic and oxidized, mobilizing some contaminants as described previously. At this point, the surface layer has characteristics similar to that of material in an upland CDF.

The bottom of an in-water CDF below the low-tide or groundwater elevation remains saturated and anaerobic, favoring insolubility and contaminant attraction to particulate matter. After dewatering of the dredged material above the flooded zone ceases and consolidation of the material in the flooded zone reaches its final state, water movement through the flooded material is minimal and the potential for migration of contaminants is low.

The intermediate layer between the saturated and unsaturated layers will be a transition zone and may alternately be saturated and unsaturated as the water surface fluctuates. The depth of this zone and the volume of dredged material affected depend on the difference in tide elevations and on the permeability of the dike and of the dredged material. With low-permeability material, the volume of CDF material impacted by this pumping is very small compared with the in-water CDF's total volume.

### 5.3.3 Analysis of Pathways for CDFs

An analysis of CDF pathways of concern must be conducted to determine if testing is warranted. Procedures used to estimate the additional potential fluxes for the in-water CDF have been used in a number of in-water CDF evaluations (Environmental Laboratory 1987; Francingues and Averett 1988; Palermo et al. 1989). These procedures are based on modeling the contaminant releases based on contaminant source terms derived from either literature or laboratory or field tests.

Brannon et al. (1990) identified key contaminant mobility processes and pathways and, where possible, methods for estimation of contaminant mass exit rates for CDFs. Pathways involving movement of large masses of water, such as CDF effluent discharge, have the greatest potential for moving significant quantities of contaminants out of CDFs. Pathways such as volatilization may also result in movement of volatile organic chemicals in highly contaminated dredged sediments at certain stages in the filling of a CDF. The relative importance of contaminant cycling and mobilization of contaminants to net mass balance in a CDF has not been determined.

The USACE has developed guidelines and a framework for the Comprehensive Analysis of Migration Pathways (CAMP) for contaminated dredged material placed in CDFs (Myers 1990). CAMP has been developed as an internally consistent set of procedures for comparing the containment efficiency of CDF disposal alternatives and, as such, for providing supporting documentation for evaluating alternatives. Existing procedures give crude estimates for some pathways.

The framework for analysis in CAMP is a tiered assessment and, as such, can be used to identify those CDF pathways which warrant more detailed assessment based on specific laboratory tests. How ever, CAMP is intended to interact with, but is not a substitute for, the existing effects-based dredged material test procedures presently used (Francingues et al. 1985; Lee et al. 1986). Additional discussion of the respective CDF pathways including appropriate testing protocols are given in the following paragraphs.

### 5.3.4 Effluent Discharge

The effluent from a CDF may contain both dissolved and particulate-associated contaminants. A large portion of the total contaminant concentration is tightly bound to the particulates. Effluent from a CDF is considered a dredged material discharge under Section 404 of the CWA and is also subject to water quality certification under Section 401 State standards.

Prediction of effluent quality should be made using a modified elutriate test procedure (Palermo 1986; Palermo and Thackston 1988) that simulates the geochemical and physical processes occurring during confined disposal. This test provides information on the dissolved and particulate contaminant concentrations. The column settling test (USACE 1987) used for CDF design provides the effluent solids concentrations. Results of both tests can be used to predict a total concentration of contaminants in the effluent. The predicted effluent quality, with allowance for any mixing zone, can be compared directly with water quality standards.

The modified elutriate test can also be used to develop the water medium for bioassays if a biological approach to evaluation of effluent quality is needed. These bioassays are conducted in a manner similar to those for open-water disposal. The quality of a reference water (usually the receiving water) should be considered in test interpretation.

If effluent contaminant concentrations exceed standards, appropriate controls should be consid ered. Control measures available for effluent discharge include improved settling design or reduced flow to the containment area, chemical clarification or filtration to remove particulate contaminants, and removal of dissolved contaminants by more sophisticated treatment processes.

### 5.3.5 Surface Runoff

Immediately after material placement in a CDF and after ponding water is decanted, the settled material may experience surface runoff. Rainfall during this initial period will likely be erosive, and runoff will contain elevated solids concentrations. Geochemically speaking, the contaminant release is controlled by anaerobic conditions. Once the surface is allowed to dry, the runoff will contain a lesser concentration of solids, but the release is now controlled by aerobic conditions, and release of some dissolved contaminants may be elevated. Runoff water quality requirements may be a condition of the water quality certification or considered as part of the NEPA process.

Presently, there is no simplified procedure for prediction of runoff quality. A soil lysimeter testing protocol (Lee and Skogerboe 1983) has been used to predict surface runoff quality with good results. The lysimeter is equipped with a rainfall simulator and can be used in the laboratory or transported to the field site.

If runoff concentrations exceed standards, appropriate controls may include placement of a surface cover or cap on the site, maintenance of ponded water conditions (although this may conflict with other management goals), vegetation to stabilize the surface, treatments such as liming to raise pH, or treatment of the runoff as for effluent (Lee and Skogerboe 1987).

### 5.3.6 Leachate

Subsurface drainage from upland CDFs may reach adjacent aquifers or may enter surface waters. Fine-grained dredged material tends to form its own disposal-area liner as particles settle with percolation of water, but consolidation may require some time for this to occur. Since most contaminants potentially present in dredged material are closely adsorbed to particles, the dissolved fraction primarily will be present in leachates.

Evaluation of the leachate quality from a CDF must include a prediction of which contaminants may be released in leachate and the relative degree of release or mass of contaminants. Although a variety of leaching tests have been proposed for various media, none have been verified for routine application for dredged material CDFs. However, experimental procedures are available for prediction of leachate quality (Myers and Brannon 1991). These procedures were based on theoretical analysis and laboratory batch testing and column testing.

The experimental testing procedures only give data on leachate quality. Estimates of leachate quantity must be made by considering site-specific characteristics and groundwater hydrology. Computerized procedures such as the EPA Hydrologic Evaluation of Landfill Performance model (Schroeder et al. 1984) have also been used to estimate water balance (budget) for dredged material CDFs (Palermo et al. 1989; Francingues and Averett 1988).

If leachate concentrations exceed applicable criteria, controls for leachate must be considered. These may include proper site specification to minimize potential movement of water into aquifers, dewatering to reduce leachate generation, chemical modifications to retard or immobilize contaminants, physical barriers such as clay and synthetic liners, capping/vegetating the surface to reduce leachate production, or collection and treatment of the leachate.

### 5.3.7 Plant and Animal Uptake

Some contaminants can be bioaccumulated in plant tissue and become further available to the food chain. If the contaminants are identified in the dredged material at levels which cause a concern, then prediction of uptake is based on a plant or animal bioassay (Folsom and Lee 1985; Simmers, Rhett, and Lee 1986). Appropriate plant or animal species are grown in either a flooded or dry soil condition using the appropriate experimental procedure and laboratory or field test apparatus. Contaminant uptake is then measured by chemical analysis of the biomass (tissue). Growth, phytotoxicity, and bioaccumulation of contaminants are monitored during the growth period in the case of the plant bioassay. An index species is also grown to serve as a mechanism to extrapolate the results to allow use of other databases, such as metals uptake by agricultural food crops. This indexing procedure provides information upon which a decision can be made regarding potential for human health effects and for beneficial uses of the site or dredged material. Levels of contaminants in the biomass are compared with Federal criteria for food or forage.

From the test results, appropriate management strategies can be formulated regarding where to place dredged material to minimize plant or animal uptake or how to control and manage the species on the site so that desirable species that do not take up and accumulate contaminants are allowed to colonize the site, while undesirable species are removed or eliminated. .

### 5.3.8 Volatilization to Air

Contaminant transport from in situ sediment to air is a relatively slow process, because most contaminants must first be released to the water phase prior to reaching the air. Potential for volatilization should be evaluated in accordance with regulatory requirements of the Clean Air Act. Thibodeaux (1989) discusses volatilization of organic chemicals during dredging and disposal and identifies four locales where volatilization may occur (volatilization is favored in the order of conditions listed):

- Dredged material exposed directly to air.
- Dredging site or other water area where suspended solids are elevated.
- Ponded CDF with a quiescent, low-suspended solids concentration.
- Dredged material covered with vegetation.

In cases where highly contaminated sediments are disposed, airborne emissions must be con sidered to protect workers and others who could inhale contaminants released through this pathway.

Rate equations based on chemical vapor equilibrium concepts and transport phenomena funda mentals have been used to predict chemical flux (Thibodeaux 1989; Semmler 1990). Emission rates are primarily dependent on the chemical concentration at the source, the surface area of the source, and the degree to which the dredged material is in direct contact with the air.

### 5.3.9 Need for Contaminant Controls

If the analysis of contaminant pathways and associated testing indicates that the standards or Guidelines, as appropriate, are met, the CDF alternative is environmentally acceptable from the standpoint of contaminant effects for that pathway. If the applicable standards or Guidelines are not met, contaminant control measures can be considered to reduce impacts to acceptable levels.

Control measures to minimize contaminant impacts may include operational modification, treat ment, site controls (e.g., liners or covers), and other site management actions. These control measures are described in paragraph 5.4. If the control measures are determined to be effective, then the alternative is environmentally acceptable from the standpoint of contaminants. If no control measures for one or more pathways are effective, then disposal at the CDF under consideration should be eliminated. .

## 5.4 Evaluation of Management Actions and Contaminant Control Measures for CDFs

In cases where evaluations of direct physical impacts, site capacity, or contaminant pathways indicate impacts will be unacceptable when conventional CDF disposal techniques are used, management actions and contaminant control measures may be considered. It should be noted that a CDF is neither a conventional wastewater treatment facility nor a conventional solids-handling facility. The dredged materials placed in CDFs typically contain 10 to 50 percent solids; therefore, an effective CDF must incorporate features of both wastewater treatment and solids-handling facilities in a combination that is unlike either (Averett et al. 1990).

Descriptions of the commonly used management actions and contaminant controls are given in the following paragraphs. Additional guidance on selection of management actions and contaminant controls for CDFs is available (USACE 1987; Francingues et al. 1985; Cullinane et al. 1986; Averett et al. 1990). These references contain testing procedures and criteria needed for evaluating and selecting appropriate contaminant control measures for CDFs, and should be consulted for additional detailed discussions of the attributes of the various technologies.

### 5.4.1 Management Actions for Physical Impacts and Storage Capacity

A number of management techniques have been developed and used that can eliminate or mini mize adverse direct physical impacts resulting from construction of CDFs. These include:

- Management of the CDF for dewatering the dredged material, thereby reducing the volume of material and reducing the need for larger or additional sites (USACE 1987).
- Treatment of effluent to remove additional solids and reduce turbidity of the discharge (USACE 1987).
- Implementation of Disposal Area Reuse Management involving removal of material from the CDF for some beneficial use, thereby restoring the capacity of the CDF (USACE 1987).
- Mitigation to include creation of alternative habitat and designated resource management onsite.
- Modification of site through landscaping and screening to improve site aesthetics and features to protect cultural resources.

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### 5.4.2 Treatment of Liquid Streams

The objective of liquid streams controls is to remove residual contaminants from the liquids produced as discharges from a CDF operation such as:

- Effluent discharges from active filling operations.
- Surface runoff.
- Leachate.
- Waters from dewatering or treatment processes.

Contaminants in these streams will present a wide array of concentrations depending on their source, and individual sources are often highly variable in concentrations and flows. Most of the contaminants for these streams are associated with the suspended solids and will be removed by effective suspended solids removal. Another characteristic of these streams is their variety of contaminants, both organic and inorganic, as well as potentially toxic contaminants. These characteristics may require more than one treatment process. Commonly used wastewater treatment processes are available to achieve effluent limits for most contaminants. However, applications of treatment processes for dredged material effluents have been generally limited to removal of suspended solids and contaminants associated with these particulates.

Liquid treatment technologies can be classified as metals removal processes, organic treatment processes, and suspended solids removal processes. Many of these processes concentrate contaminants into another phase, which may require special treatment or disposal. This discussion focuses on suspended solids, toxic organics, and heavy metals. Conventional contaminants, such as nutrients, ammonia, oxygen-demanding materials, and oil and grease, may also be a concern for dredged material effluents. Most of the processes for dissolved organics removal are suitable for these contaminants.

#### 5.4.2.1 Suspended Solids Removal

Suspended solids removal is the most important liquid streams technology because it offers the greatest benefits in improving effluent quality not only by reducing turbidity but by removing particulate-associated contaminants. Suspended solids removal processes differ from dewatering processes because for this application the solids concentration is much lower than for a dredged material slurry. Settling mechanisms for these streams are characterized by flocculent settling rather than zone or compression settling. For CDF liquid streams, the solids remaining will be clay or colloidal size material that may require flocculants to promote further settling in clarifiers or sedimentation ponds. Chemical clarification using organic polyelectrolytes is a proven technology for CDF effluents (Schroeder 1983). Filtration, permeable dikes, sand-filled weirs, and wetlands have also been used on occasion for CDF demonstrations or pilot evaluations. More detailed guidance on suspended solids removal processes as applied to CDFs is available (USACE 1987; Cullinane et al. 1986).

#### 5.4.2.2 Metals Removal

Metals removal processes that may be considered for application at CDFs are similar to those commonly used for industrial applications. Processes that are developmental and less likely choices are biological ion exchange, electrocoagulation, and ultrafiltration. Flocculation is effective for removal of metals associated with particulate matter. Polymers and inorganic flocculants have been demonstrated to be effective for removal of suspended solids from dredging effluents, but removal of dissolved heavy metals has not been evaluated in field applications. Ion exchange and precipitation are probably two of the more efficient metals removal processes, but they must generally be designed for specific metals and often require major investments in operational control for efficient operation. Use of man-made wetlands is a relatively new concept for retention of heavy metals and other contaminants from effluents, which could represent a viable option for certain sites and contaminants (Fennessy and Mitsch 1989). Flocculation/coagulation, ion exchange, permeable treatment beds, precipitation, and created wetlands are recommended for additional consideration for the EPA's ARCS (Assessment and Remediation of Contaminated Sediment) program (Averett et al. 1990). More detailed guidance on metals treatment processes as applied to CDFs is available (Cullinane et al. 1986; Averett et al. 1990).

#### 5.4.2.3 Organics Treatment

The applicability and effectiveness of options for treatment of dissolved organic contaminants are mostly dependent on the concentration and flow rate of the liquid stream. Mechanical biological wastewater treatment processes are typically not considered because it is doubtful that sufficient organic matter would be available to support biological growth and because operation of biological systems under the conditions of fluctuating flows and temperatures would be difficult. Biological processes such as nitrification, nutrient catabolism, and photosynthesis are important degradation mechanisms for nutrients, oxygen-demanding materials, and other organics in CDFs. The principal process for dissolved refractory organic contaminants that has been applied to dredged material effluent is carbon adsorption, which was applied to a PCB spill on the Duwamish Waterway in the 1970's (Blazevich et al. 1977). Air and steam stripping could be used for volatile contaminants, but these are generally not a problem for contaminants originating in most dredged sediments. Ultraviolet light (UV) and chemical oxidation processes offer destruction of organic contaminants and are being extensively investigated in the field for a wide range of contaminants. Created wetlands also offer potential for retention and degradation of organics. The more effective organic treatment process options are:

- Carbon adsorption.
- Chemical oxidation using ozone.
- UV/hydrogen peroxide.
- UV/ozone.
- Oil separation.
- Powdered activated carbon.
- Resin adsorption.
- Steam stripping.

- Created wetlands.

More detailed guidance on organics treatment processes as applied to CDFs is available (Cullinane et al. 1986; Averett et al. 1990).

### 5.4.3 Site Controls

Site controls (e.g., surface covers and liners) can be effective control measures applied at a CDF to prevent migration of contaminants from the dredged material (Cullinane et al. 1986; Averett et al. 1990). The implementability and effectiveness of these controls is highly specific to the CDF location and the dredged material characteristics.

Use of site controls such as liners, slurry walls, groundwater pumping, and subsurface drainage are limited in most nearshore, in-water CDFs. Graded stone dikes with sand or steel sheet pile cutoffs have been used or proposed at upland CDFs and a few in-water CDFs to control leachate migration. The low permeability of fine-grained sediments following compaction can reduce the need for liners in many cases, but it can also limit the effectiveness and implementability of groundwater pumping and subsurface drainage controls.

A cover can be highly effective in reducing leachate generation by avoiding rainfall infiltration, isolation from bioturbation and uptake by plants and animals, minimizing volatilization of contaminants from the surface, and eliminating detachment and transport of contaminants by rainfall and runoff. A layer of clean material can achieve the last three benefits mentioned. However, prevention of infiltration requires a barrier of very low permeability, such as a flexible membrane or a compacted clay layer, both of which are not easily or reliably implemented for CDFs. Other leachate control measures include groundwater pumping, liners, subsurface drainage, sheet pile walls, slurry walls, and surface drainage. Liners have not been used extensively for contaminated dredged material sites because of the inherent low permeability of fine-grained dredged material, the retention of contaminants on solids, and the difficulty and expense of construction of a reliable liner system for wet dredged material, particularly for in-water or nearshore sites. Leachate collection techniques, such as groundwater pumping and subsurface drainage, have been evaluated in a limited number of situations, but these techniques appear to have limited feasibility for in-water sites. Sheet pile walls and slurry walls can be used to provide barriers to leachate and seepage movement from a CDF. To be effective, the barrier should tie to a geologic formation with very low permeability. Sheet pile walls are not leakproof and deteriorate over time; therefore, they should not be considered as a primary containment measure. More detailed guidance on site controls for CDFs is available (Cullinane et al. 1986; Averett et al. 1990).

### 5.4.4 Treatment of Dredged Material Solids

Various treatment processes have been proposed for dredged material solids (i.e., the mass of dredged material following placement within a CDF) or dredged material slurries. These processes fall under one of the following categories: bioremediation (use of bacteria, fungi, or enzymes to break down organic contaminants), chemical treatment (e.g., oxidation, reduction, chelation, hydrolysis, detoxification, nucleophilic substitution, and thionation processes), extraction (removal of contaminants by dissolution in fluid), thermal (e.g., incineration), and immobilization (processes which limit the mobility of contaminants).

Some of these treatment processes have been applied in pilot-scale demonstrations, and some have been applied full scale. Several are to be demonstrated under the USEPA ARCS program. The relatively high cost of such treatment alternatives is a major constraint on their potential use.

The potential for implementation of immobilization processes is better than other treatment pro cesses, because they are not as sensitive to process-control conditions. The opportunity for applying these processes in situ in a CDF is also an advantage.

The environmental pathway most affected by immobilization processes is transport of contami nants as leachate to the groundater or surface water. Most of the immobilization processes fall into the category of solidification/stabilization (S/S). Objectives of S/S are generally to improve the handling and physical characteristics of the material, decrease the surface area of the sediment mass across which transfer or loss of contaminants can occur, and/or limit the solubility of contaminants by pH adjustment or sorption phenomena. Effectiveness of S/S processes is usually evaluated in terms of reduction of leaching potential. Reductions are process and contaminant specific, with immobilization of some contaminants accompanied by increased mobility of other contaminants.

### 5.4.5 Site Operations

Site operations can be used as a control measure for CDFs to reduce the exposure of material through the surface water, volatilization, and groundwater pathways. Operational controls may include management of the site pond during and after disposal operations. Mobilization of contaminants from dredged material depends on the oxidation state of the solids. Most metals are much less mobile when maintained in an anaerobic reduced condition. On the other hand, aerobic sediments generally improve conditions for biodegradation of organic contaminants. Aerobic sediments generally present the greatest potential for volatilization of contaminants (Thibodeaux 1989). Ponded conditions that normally exist in nearshore or in-water CDFs can limit volatilization. Maintaining ponded water on the site produces a hydraulic gradient that increases the potential for movement of leachate through the site. Whether to cultivate or inhibit plant and animal propagation is also an issue. Management of the site both during filling and after disposal requires a comprehensive understanding of the migration pathways and the effects various contaminant controls have on the overall mass balance and rate of contaminant releases. The decision to apply certain management options requires trade-offs for the site and contaminant- specific conditions for the project.

## 5.5 Retention of Environmentally Acceptable Confined Alternatives

Once appropriate confined-disposal tests and assessments are complete, a determination of environmental acceptability can be made. This determination must ensure that all applicable standards or criteria are met. If control measures were considered, a determination of the effectiveness of the control measures in meeting the standards or criteria must be made. If all standards or criteria are met, the confined-disposal alternative can be considered environmentally acceptable. At this point, other factors can be considered in the selection of an alternative as described in paragraph 3.6 and Chapter 7.